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ABSTRACT

This paper examines the role of systems thinking in higher education, explaining that university examples provide a sense of what systems thinking entails when applied within large, complex organizations. It shares insights provided by the system dynamics approach for approaches to organizational leadership in education. A system dynamics approach aims to identify how streams of decisions and resources interact to produce behaviors recognized as problematic for an organization (for the purpose of intervention and performance improvement). The system structure is based on two types of feedback loops: positive (self-reinforcing) and negative (self-correcting or balancing). Archetypes are systems thinking tools that can help construct dynamic pictures of the operation of various systems, providing assistance in diagnosing, predicting, and addressing problems in organizational behavior by identifying structures responsible for such behaviors. The paper presents a sample of archetypes and examples of their occurrence in educational settings (e.g., attempts to introduce and spread technology use throughout the curriculum in all schools in a district). It describes systems thinking and university structures, highlighting publicly funded institutions that have recently faced more stringent operating environments. It concludes by illustrating how a systems approach helps at a wider institutional level. (Contains 15 references.) (SM)

Systems Thinking: a lens and scalpel for organizational learning

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Introduction

Since the term *systems thinking* is used by different individuals and groups, with a variety of meanings, I will begin by identifying the paradigm out of which I am writing as *System Dynamics*. Some will recognize this as the discipline underpinning the approach to organizational learning set out in the *Fifth Discipline* (Senge, 1990; Senge, Roberts, Ross, Smith & Kleiner, 1994) and related works-where it is called *systems thinking*. In this paper I intend to share insights that I believe the system dynamics approach provides for approaches to organizational leadership in education. In doing so I apologize in advance to those who may be from that field, and hence familiar with issues and examples similar to those introduced here.

It is worth clarifying that leadership of learning organizations, approached from a system dynamics perspective, adds a dimension not encompassed in the discussion of other leadership styles (transactional, transformational, moral, charismatic...) that have received attention in recent times (Yukl, 1997). As the literature confirms, these are behaviorally based, with emphases on how leaders relate, cajole, inspire, and encourage involvement in organizational activity; no criticism of these leadership models is implied. The additional dimension involves utilizing the importance of structural relationships for planned and sustained change. A practice common among social scientists, of labeling theories by means of their prominent authors, has found some already prepared to label systems thinking and its distinctive approach to organizational learning as circa Senge (1990), and hence by implication dated. This superficial stance is guilty of the same error as one that confuses the pioneering work of Newton with the theory of gravitation. As the theory of gravitation was developed, extended, and refined by subsequent generations, so the structural theory underpinning the approach to learning organizations (system dynamics) continues to be developed, and applied. (System dynamics predated the Fifth Discipline by 30 years-a rigorous state-of-the-art work is Sterman (2000)). And application to the art and practice of the learning organization as initially presented in Senge (1990), has been developed and extended through the medium of fieldbooks to advise on the practice of implementation (Senge et al., 1994), through issues of sustainability (Senge, McCabe, Kleiner, Roberts, Ross, Roth & Smith, 1998), to include a specific educational emphasis (Senge, McCabe, Smith, Kleiner & Dutton, 2000).

From this systems viewpoint decision-makers can be considered information converters, receiving incoming information flows and combining these into streams of managerial actions. However most discussion around this theme seems to be organized as in Fig 1(a).

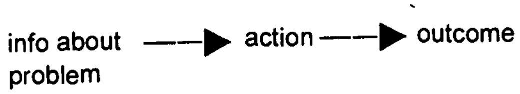


Fig 1(a). Linear Cause-Effect Chain

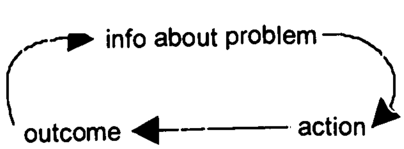


Fig 1(b). Circular Cause-Effect Chain

In other words some information about a problem is identified, some action is proposed, and an outcome is expected. But in practice the expected outcome often does not materialize, and the reason for this is contained in the alternative structure of Fig 1(b), which more realistically portrays the relationships at work (Forrester 1994). The problem symptom, action, and outcome are not isolated in a linear cause-effect sequence but in a closed chain of causality (feedback loop) whereby, for example, the outcome of the first action provides new information which forms the basis for further action and so on. An action may not necessarily reduce the problem symptom, but may cause fluctuation or indeed even accentuate the very factors that produced the symptoms in the first place. Let us take a non-educational example: the problems we find easiest to solve are 'local' in space and time. There is indeed no need to cry over spilt milk (Richmond 1991), for the spill is contained in the immediate area and easily removed without further consequences. The same cannot be said about the 'spill' of pollutants, which has consequences far beyond the immediate in both space and time. Current moves for more stringent emission controls can be recognised as consequences of earlier industrial practices, reverberating through a series of industrial, environmental, economic, and political relationships to impact years later at the source of the problem—levels of industrial pollutants released into the atmosphere. A disciplined approach to systems thinking is needed to trace circular chains of cause and effect through intermediate stages, and to articulate the associated mental models that provide the key to alternative outcomes. And of course this applies equally within educational organizations. An interesting challenge is to identify a chain that might link current government initiatives in literacy and numeracy with former educational decisions and practices.

Methods

A System Dynamics approach aims to identify how streams of decisions and resources interact to produce behaviors recognised as problematic for an organization, for the purpose of intervention and performance improvement. It takes a view with respect to responsibility, shared by individuals as diverse as Shakespeare '*The fault dear Brutus, is not in our stars but in ourselves that we are underlings*'; and the cartoon character Pogo: '*We have met the enemy, and he is us.*' That is, most persistent organizational problems are of our own making, and while external events can impact severely, the long-term quality of organizational responses is ultimately a consequence of internal decision making, and of the structure within which actions are framed and implemented. So the articulation of structure becomes the focus and has three significant components.

1. The relationship between elements that interact in actual decision-making processes
2. The identification of circular chains of causality (cycles) formed from such links
3. The estimation of time delays that act to induce lags in action-impact links and hence in the cycles.

System behavior may be inferred in simple cases from standard loop properties (archetype approach). In more complex cases intuition cannot be trusted, and models must be developed and behaviors simulated to seek and test intervention strategies (simulation approach).

Lens and Scalpel

To provide the *lens* dimension it is useful to introduce the concept of "viewing distance" for which a traffic analogy is helpful. A driver's view is preoccupied with the detail of the immediate environment; his or her operation of the driving controls, fuel and temperature readings, the detail of surrounding vehicles and their passengers, immediate obstacles to progress such as traffic lights etc. A driver is not however in a position to observe traffic patterns in the wider road system, and needs to tune in to traffic reports for advice to avoid potential (system) problems. Secondly we consider the view from an observer at traffic control headquarters. Here foot and hand movements of individual drivers are not visible, individual intentions are not accessible, small differences between vehicles are blurred. But very evident are the overall flow patterns in the area, how these are being affected by sets of traffic lights, disabled vehicles, lane closures, accidents and so on. This is a systems view in which the behavior of the whole is understood only through the interrelation of the individual parts, not merely through the presence of the parts. So it is with a systems approach to organizational management and learning.

Leaders of organizations need this 'systems perspective' to complement experience gained in the hurly-burly of what Richmond (1991) refers to as 'the fray'. Most of our experience in organizations resembles the driver in traffic, rather than an observer at Traffic Control. We're in the 'traffic flow', reacting to emergencies, writing memos, attending meetings, meeting that parent, planning that new course, refurbishing the laboratory, making decisions on the run, and so on. Living in the 'fray' we've developed an arsenal of fray conditioned responses; look after the immediate problem and hope the ramifications of our decisions don't return to hurt us. All this reinforces our propensity for one-way thinking, actively subverting the systems view that searches for chains of consequences to inform future actions. The tools of systems thinking are provided to develop this complementary view, whose attainment is threatened when never ending demands for new initiatives diffuse the intensity with which necessary planning needs to be engaged.

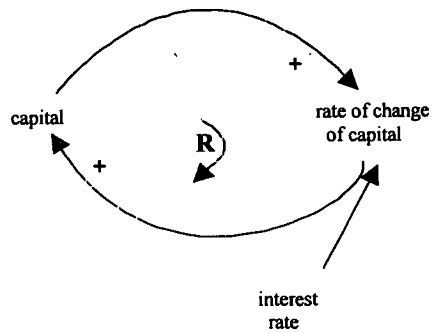
The *scalpel* dimension focuses attention on systemic relationships; this time in the sense of Occam's razor, seeking the identification of key structure to provide leverage for change, and means for sustaining change. This means identifying the major growth and balancing processes and the nature of their combination, together with delays that impact on their activity, so influencing outcomes. In doing so superfluous detail needs to be identified, assessed, and discarded, a difficult exercise when pet fads and fancies may be involved

The applications in this paper will be to problems associated with organizational challenges in schools and universities.

System Structure

All dynamics in systems arise from the interaction of just two types of feedback loops; *positive* (self-reinforcing) and *negative* (self-correcting or balancing) loops.

An example of a simple *reinforcing* loop (R) is the compound interest process in which interest added to invested capital increases the capital, which increases the interest in the next time-period, which increases the capital and so on. Arrows on links have the following meaning: '+' means that the entity at the head moves in the same direction as the entity at the tail, while '-' means that the entity at the head moves in the opposite direction to the entity at the tail.



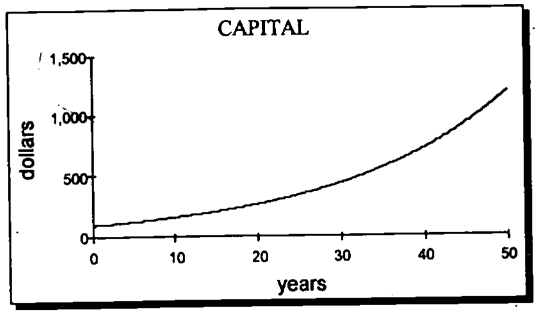
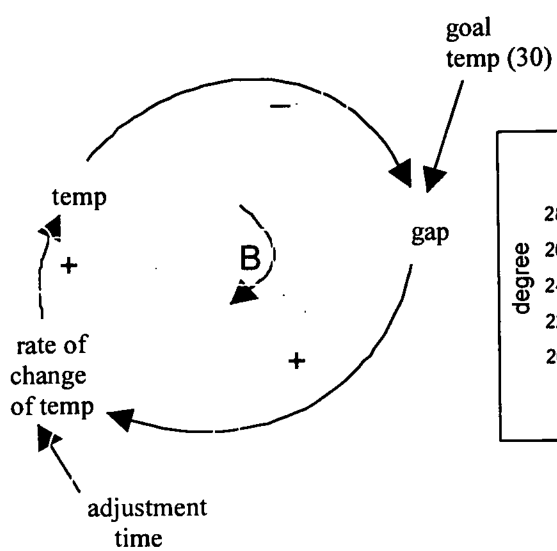


Figure 2(a). Reinforcing loop structure **Figure 2(b). Reinforcing loop behavior**

If unchecked, reinforcing feedback results in exponential growth, but in practice inhibiting factors ensure that unlimited growth cannot occur forever. And a reinforcing loop running in reverse generates collapse.

A simple *balancing* loop is illustrated by a thermostat controlling room temperature, where the thermostat setting represents a goal temperature. All balancing loops have a common feature (*a goal*); and the gap between the goal and the current state is the source of action that aims to close the gap over an adjustment time-here determined by the heater setting



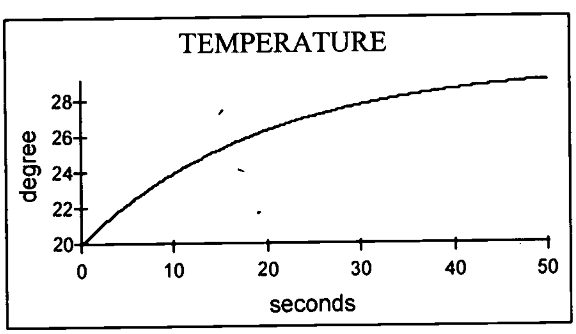


Figure 3(a). Balancing loop structure **Figure 3(b). Balancing loop behavior**

If the temperature falls below the desired level (set here as 30 degrees C), the furnace is activated until the room temperature is restored. The thermostat loop is stabilizing because a decrease in temperature causes, through the control mechanism, an eventual increase in room temperature through activation of the furnace. The ability to control is complicated by the occurrence of delays in loops, which means that action may be continued for longer than is necessary to reach the goal. The result is overshoot and undershoot, as for example when the delay between adjusting the hot tap in a shower and the impact of hotter water results in excessive hot and cold water being released with uncomfortable future consequences. In this case there is oscillation around the goal rather than a smooth approach to it.

The presence of multiple loops containing a variety of delays is the source of complexity that makes social systems so difficult to predict and control. In a university, for example, an example of a reinforcing loop is the process by which an increase in enrollments provides additional funds which supports an increase in academic staff which provides for the enrollment of more students which produces additional funds and so on. An example of a balancing loop is the process by which an *increase* in staff increases the salary bill which reduces the funds available to employ staff which reduces the rate at which new staff can be appointed which leads to a *reduction* in staff etc. In both of these causal loops, delays of the order of years are involved before the loops are closed.

Other examples of simple negative feedback include; the hiring activity of a firm that is expanding its workforce to a target figure over a given time; the armament procurement policy of a nation that sets its goal from perceptions of a security threat; the work activity of an individual who has a savings goal or a debt deadline to meet; implementation of a school discipline policy based on a goal of reduced student misbehavior, an academic intervention program aimed to increase the performance of a school in terms of student grade achievements.

Archetypes

Archetypes are systems thinking tools we can use to construct dynamic pictures about the operation of systems with which we work. They provide assistance in diagnosing, predicting, and addressing problems in organizational behavior through the identification of structures responsible for such behaviors. Archetypes are comprised of reinforcing and balancing loops in various combinations. A comprehensive treatment is contained in (Senge et al., 1994: 121-172). In the following a sample of archetypes will be presented together with examples of their occurrence in educational settings, and related implications.

1. Limits to growth

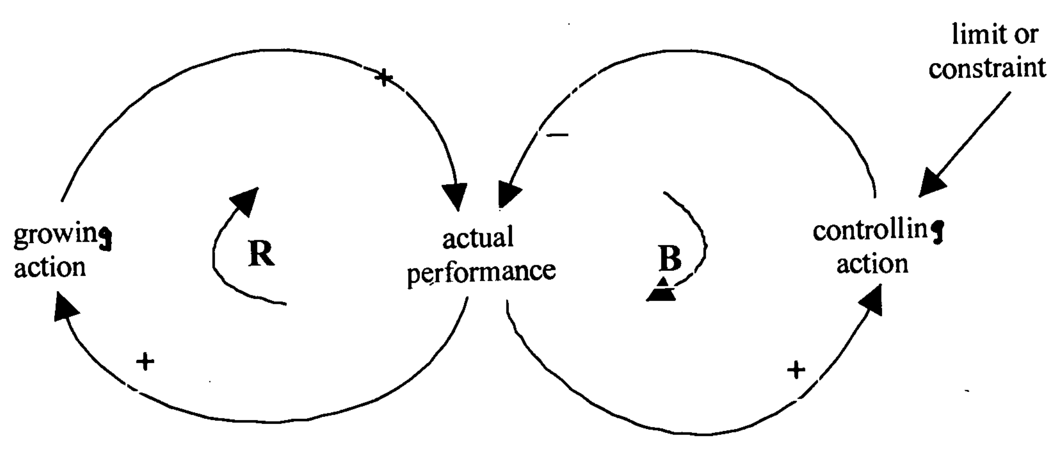


Figure 4(a). Limits to growth structure

The most basic 'limits to growth' structure contains a reinforcing loop and a balancing loop. The balancing loop reacts to imbalances generated by the growth loop. As actual performance (the growing quantity) grows the balancing loop kicks in, driven as it is by its target. Like the thermostat setting, the target represents a limit or constraint on the whole system.
The outcome is the familiar sigmoidal growth pattern, that describes the growth of an organism, the spread of an infectious disease, the sale of a popular new product, the spread of an innovation and so on.

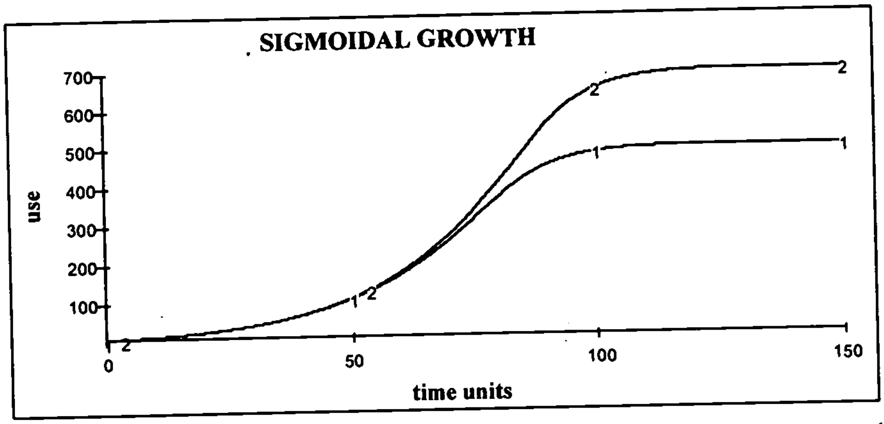


Figure 4(b). Limits to growth behavior (Units on axes are arbitrary).

Educational example
As an educational example we have all attempts to introduce and spread new approaches eg the use of technology throughout the curriculum in all schools in a district or state.
The growth loop on the left describes the initial phase before the growth limit becomes a factor, when enthusiasts take up the challenge and the rate of growth appears unlimited. The balancing loop depicts the process that curtails the growing rate, as the difference between present population and potential population decreases. If no other factors are at work the population will approach the carrying capacity as shown in graph 2.
However other factors are often at work. In the biological case a growing organism produces toxins whose cumulative effect can cause growth to cease before carrying capacity is reached, as in graph 1. (Of course these graphs are ideal types, and actual growth patterns are lumpy-but the behavior mode is robust).
Two matters of significance can be noted. Firstly growth in a finite environment cannot maintain buoyant levels indefinitely, at its best it must asymptote to the carrying capacity. Secondly side-products (toxins) may be produced which inhibit the growth so that this potential is not realized.
Applied to social contexts (including schools) there are other influences at work. In the early growth phase optimism reigns as the rate of growth continues to increase. The world is buzzing as new members join and the 'movement' grows. When the gradient passes its maximum, as it must in a finite world, there is a sense of loss of momentum. A possible social outcome is the feeling that the innovation has had its day, when in fact it is following a natural growth pattern. Simultaneously social side effects may be produced with toxic effects on growth, just as inhibiting as the waste products that impede the growth of biological populations.
Let us apply this thinking to the growth of an imaginative technology, such as the use of graphics calculators in mathematics, or web based learning in any subject.

Enthusiasm generated among pioneering practitioners, together with support from official sources, generates increasing numbers of users-this is presently occurring in some systems. How will future usage patterns emerge? As a coarse approximation we could consider the potential capacity as the number of classrooms in which the technology might be used. However various other bounds can impose lower limits on actual growth, a most obvious one being the availability of facilities and hardware. Clearly a lack here will curtail growth. But suppose there are no such physical limits, and schools are resourced so that every classroom is equipped with the necessary means. Now growth is no longer limited by hardware, and a new potential limit emerges-such as the overall skill level of the practitioner population. Suppose now that training programs provide expertise, so that in theory this limit is lifted also. Inhibiting forces are almost certain to remain and they are not the consequence of either physical or skill limits. While rapid initial growth takes place among believers whose enthusiasm feeds the growth further, resistance will be encountered from continuing non-converts. This resistance may be philosophical, based on concerns that important skills are being compromised; or psychological as a reaction to the excessive enthusiasm of peers, and perceptions that valued forms of learning are being extinguished or marginalised. And these influences are not confined to the teaching fraternity; they can be exerted through parent opinion and other community groups. This circumstance might be recognized as a social analogue of toxin production, a product of existing growth that acts to inhibit further growth. The overall point is that growth-limiting conditions can shift between physical (including financial), skill, philosophical, and psychological influences. Each needs to be addressed, and the necessary methods are different. There may be more than one reinforcing process and often many balancing processes exist, nearly all invisible at the start. A systems principle is not to perpetually push against limits, but to seek ways to relax or remove them-the antithesis of 'crash through or crash'. Rather look to introduce other reinforcing processes or find ways to incorporate limits in the next wave of expansion. And at the outset of an initiative, which is the best opportunity for intervention, a systems perspective would try to anticipate balancing processes that will work against desirable growth, particularly those with delays that may not kick in for some time.

2. Shifting responsibility

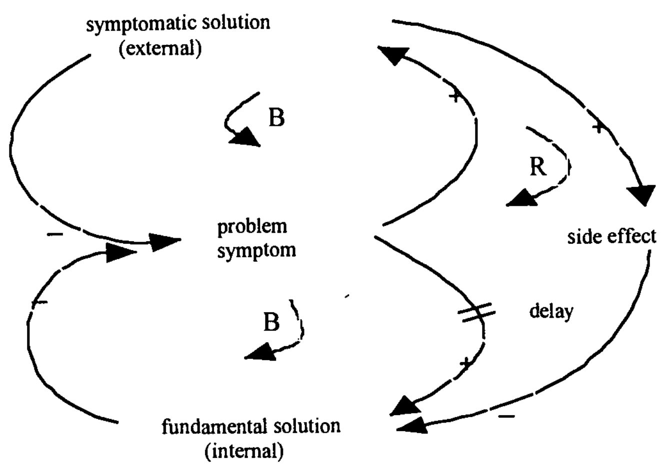


Figure 5. Shifting Responsibility structure

An external agent is used to correct a 'problem' with apparent positive results. As this approach is used more and more, the power to provide an internal solution (which sometimes takes longer) is continuously eroded (and perhaps disabled) leading to increased dependence on the external solution and further powerlessness within. Structurally we see that both forms of intervention (external and internal) act to reduce the symptom via the respective balancing loops. The goals of the respective balancing loops are implicitly zero-since the target is elimination of the problem symptoms. However, the problem behavior is a consequence of the reinforcing loop, through which an increase in the problem symptom leads to external intervention, which leads to a reduction of the capacity of internal actors, which weakens the effectiveness of the internal solution, which leads to a further increase in the problem symptom, thence to further external intervention and so on. One of the most vivid educational applications of the *Shifting Responsibility* archetype occurs in the story of Helen Keller. Helen as a severely disabled girl learned that her parents would rush to her aid, their very protection eroding her capability to cope with her world. Anne Sullivan as her teacher sensed that the fundamental long-term solution was to move responsibility to Helen herself and away from the external intervention, which weakened both the resolve and the capacity to achieve self-actualization. The rest, as they say, is history.

Educational Example

With school based management, one of the decisions facing leaders is how to allocate resources to address problems of learning, behavior, and special needs provision. A principal may for example elect to bring in a non-educational consultant such as a specialist psychologist or other diagnostician, or alternatively to use someone internal to the school, trained in diagnosis but who is also a trained teacher. (Known variously as School Counselor, Guidance Officer or some such title). The first option is an external intervention, which may provide information about the specific circumstances-but that leaves the teacher to design appropriate educational responses, individual programs etc. In the second option there will again be diagnosis but also support in the school, and educational expertise to work with the teacher to design an appropriate learning or behavior management program. In the first case the teacher remains dependent and stands to have her/his confidence undermined if the external intervention becomes a regular event. In the second case the teacher's own skills and confidence stand to be increased, through the support of one who has special diagnostic expertise but is also a skilled professional colleague. The systems view argues that the second option stands a much better chance of strengthening the internal capacity of the school to address problems, by refraining from shifting the responsibility to an external agent. Such insights are relevant when significant resource decisions are debated-such as whether to out-source problems to professional consultants, or to invest in strengthening the skill base of internal staff. The concept behind this archetype can be widened beyond the internal – external dimension embedded in the foregoing. The archetype applies whenever a short-term solution generates a side effect (in the above case weakened internal capacity) that reinforces a dependency at the cost of a fundamental solution. At an individual level we have alcohol or drug dependency induced by substance abuse as a short-term solution to problems that really require a fundamental review of internal stress creating circumstances. Any other addiction may be analyzed similarly. In a school or university there may be efforts directed to propping up elements of existing practices with just enough success to weaken the resolve to undertake the fundamental changes that are really needed for future health. Drawing a systems diagram helps to make issues public in ways that both make them more structurally visible, and facilitate serious discussion by distancing them from individual responsibility and self-esteem.

3. Sliding goals

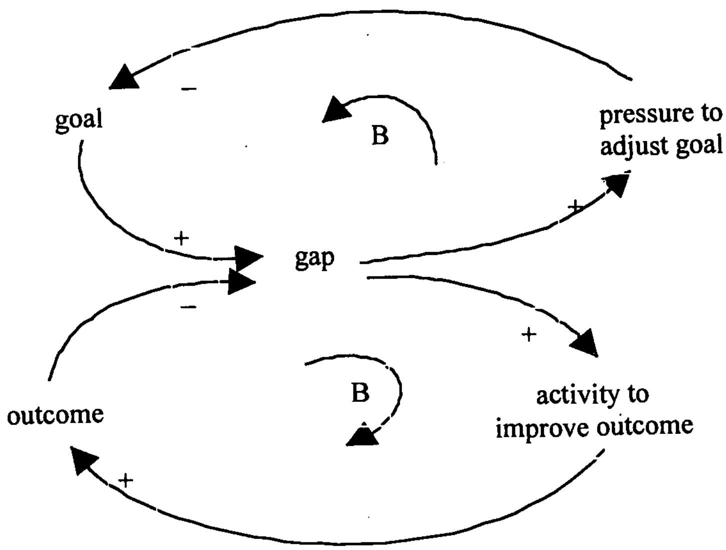


Figure 6. Sliding goals structure

A gap, defined as (goal – outcome) emerges that gives a picture of how far our efforts are falling short of the ideal. In this structure when the gap widens there is pressure to adjust the goal downwards (top loop) as well as to increase activity (bottom loop) so as to close the gap. If the pressure to adjust the goal prevails then as this process continues, successive iterations cause a downward drift in aspirations, and performance follows as activity adjusts to meet the lowered goals. The effect is like having a thermostat where the ideal temperature is not fixed, but is allowed to drift downward as the actual temperature becomes more extreme. The archetype is particularly pernicious in its capacity to erode performance while actors still see themselves as maintaining quality. Examples are many, from individuals who become less successful because they lower their own expectations, to governments who revise goals e.g. for the reduction of unemployment, to make them easier to approach.

Educational example

Within education examples are numerous with 'dumbing down' a current term pointing to its presence. Falling academic performance may be met not with a reduction in the number of students awarded high grades but with a lowering of the quality needed for the award of such grades with associated pressures compounded by student and parent expectations. A ninety percent achievement of objectives set for a school literacy program may in itself be a reason for celebration, and yet a source of future problems if it is allowed to become the comparison measure for next year's success and so on. Assertive discipline programs may founder because teachers and/or administrators fail to adhere to the totality of implementation that is required for success. Ironically because many innovative programs are seen to be much better than a previous vacuum even when partially implemented, the significance of holding the goal for future quality is often not recognised. The management principle so essential in a situation susceptible to sliding goals is "hold the vision", not an easy choice when pressures emerge to constrain expectation to performance rather than vice versa. And it is some comfort to realise that great school leaders and great teachers continue to exist in a world increasingly cynical about the capacity to demand high quality (however defined) in the face of continuing pressures to lower expectations. The sliding-goals archetype however has a silver lining. The upper loop also provides the means for raising expectations rather than lowering them by increasing what is considered to be the goal achievement level – let us *beat* last year's performance. As with most archetypes the sliding goal structure has an identifiable presence within individuals, within classrooms, and organizationally at school level, district level, and indeed at state and national levels.

Systems Thinking and University Structures

It quickly becomes clear that there is no single definition of 'University' that encompasses the wide range of institutions that share this name, and the national contexts in which they are located. So it is proposed here to delimit the problem by defining the context to be that associated with publicly funded institutions that over the last decade or so have faced a more stringent operating environment. This has included funding curbs and increased demands for accountability, leading to the development and application of a range of performance indicators, and devolution of managerial responsibility such that academic aspirations have come into increasing conflict with fiscal goals-dollarship versus scholarship. Such circumstances are found amongst Australian and UK universities for example. A generic structure that appears repeatedly within the competitive organizational structure of publicly funded universities occurs when institutions distribute a substantial proportion of funds on the basis of student load. The structure describing this process is shown in Figure 7, and represents a proportional mechanism with 'equivalent full-time student' (efts) the unit around which the process is based.

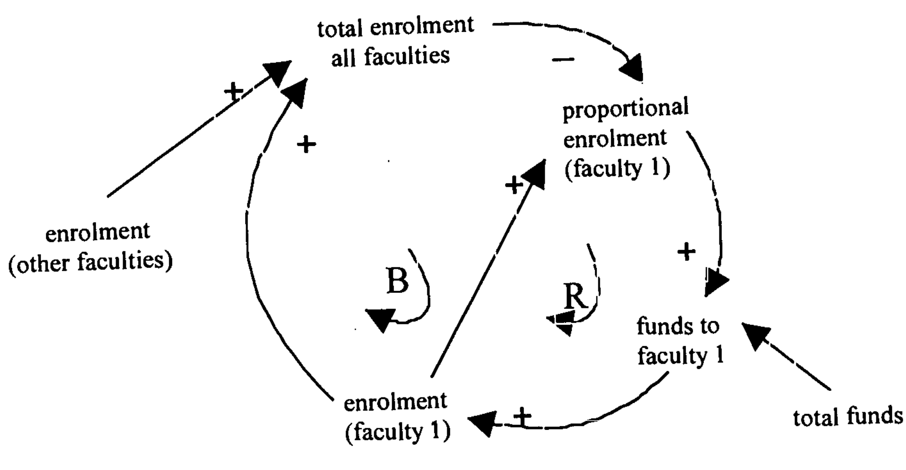


Figure 7. Generic student load funding loop

While an increase in a faculty enrollment increases student load and hence tends to increase dollars earned (reinforcing loop), it also increases the total load for the university, reducing the dollar value received per student when the total funding is limited (balancing loop). The positive impact of higher enrollment is negated by the lower return received per enrollment. Thus a faculty can grow in student numbers and yet suffer a reduction in funding if there is greater relative growth elsewhere in the institution. Faculties normally prefer to bear the burden of over enrollment, rather than run the risk of having funds withdrawn through failing to meet quotas. So under conditions where the total university grant is frozen, the worst possible circumstance is to be the slowest growing unit (in student terms) in a growing institution. Proportional formulae operate on the assumption that all other things are equal apart from numerical size that the formula is designed to provide for. But across a university other things are far from equal and such formulae ensure that in these circumstances winners and losers must emerge. Such insights are important in forming expectations and in evaluating performance.

A second generic structure operates in the other major area of academic activity (research). This circumstance emerges when competing units act in their own best interests to maximize their individual share of a limited resource. The situation may be recognised as a version of the *Tragedy of the Commons* as described by Hardin (1968).

"The tragedy of the commons develops in this way. Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons. Such an arrangement may work reasonably satisfactorily for centuries because tribal wars, poaching, and disease keep the number of both man and beast well below the carrying capacity of the land ... The rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd. And another ... But this is the conclusion reached by each and every rational herdsman sharing a commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit – in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons beings ruin to all."

A 'tragedy of the commons' arises whenever two conditions are operative:

(1) There exists a 'commons' or a limited resource shared among a group of competing units; and

(2) The units are free to dictate their own actions so as to maximise their own gain from the 'commons'.

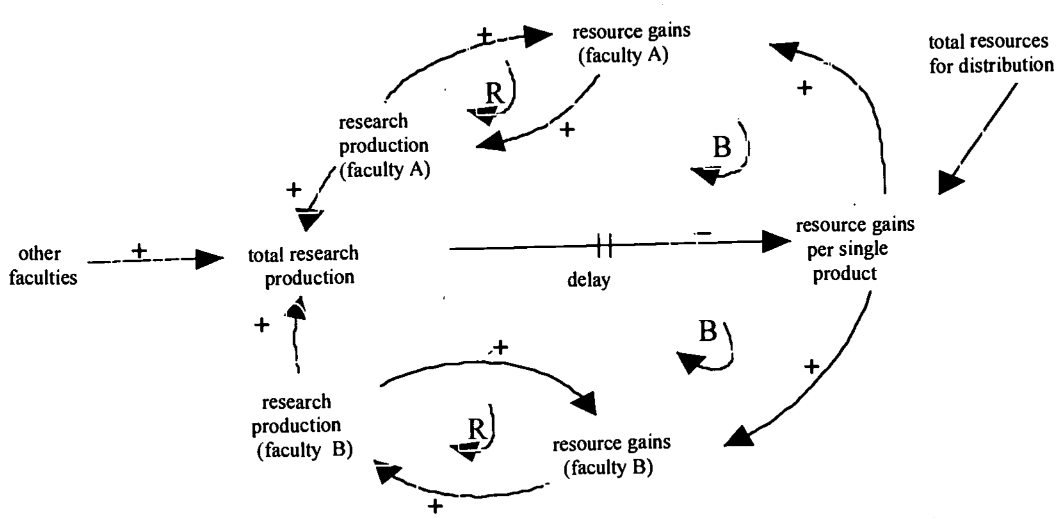


Figure 8. Generic research funding loop

The relevant structure for the university context is shown in Figure 8 in a scaled down form (for two faculties). By working harder both A and B contribute more products to the total pool, which in a resource limited setting means less funds are returned per product. Eventually the reduction impacts on the capacity to produce and the effectiveness of A and B is compromised or destroyed.

Now there are some recognised principles for managing a commons (Kauffman, 1980; Senge, 1990) that involve either voluntary or legislated limits on individual exploitation. Universities, keen to encourage and reward the research excellence of their academic members provide incentives through the allocation of a proportion of operating grants to faculties on the basis of their relative performance, say, in grant winning, publications and graduation of thesis students. As with enrollments, when total funds remain relatively steady greater productivity results in a lower return per product. Every additional grant won, every additional paper published, and every new thesis student graduated ensures that less income is received for that particular product than the previous one. More and more effort is required just to maintain a relative position. A faculty or school working at maximum efficiency has nowhere to go but down, and smaller units are particularly vulnerable when total output is the criterion. Now there are clear similarities between the structures shown in Figures 7 and 8, but also important differences. Although proportional policies are enacted in both, for the enrollment sector, a mixture of natural processes (waxing and waning of demand) and legislated limits on access (quotas) serve to protect the common resource from excessive plundering by any particular faculty or school. Put another way principles for managing a commons act fortuitously to limit excesses in relation to enrolment pressures although these may be still severe. There are no such natural restraints within the research sector, as perceived monetary rewards to institutions and faculties, and promotional rewards to individuals based on increased research production drive the process so that units and individuals work harder and harder for less and less return per effort.

Through its viewing perspective and structural synthesis the systems approach suggests a way to ameliorate the worst excesses of a 'tragedy' policy, but this involves preserving a portion of the 'commons' from quantity based free-for-all competition in favour of allocation based on quality. It involves allocating a proportion of available funds on the basis of agreed levels of performance, irrespective of the actual number of products produced. In this way a faculty or school that is losing staff on account of financial stringency may obtain some compensating reward if the remaining members maintain high quality performance.

Institutional Model Structure

Having concentrated thus far on the identification and implications of systems archetypes we conclude by illustrating how a systems approach assists insight at a wider institutional level. This can be a precursor to simulation modeling that is fundamental to further implementation of the system dynamics approach, but is beyond the purpose of this paper. The representation of university structure for model purposes contains the structures of Figures 7 and 8 in various combinations, linked with complementary structure that embodies debt management strategies and associated staffing policies. Figure 9 shows a loop diagram generated by applying systems thinking to the student load sector of Faculty operations with associated budget and staffing structures.

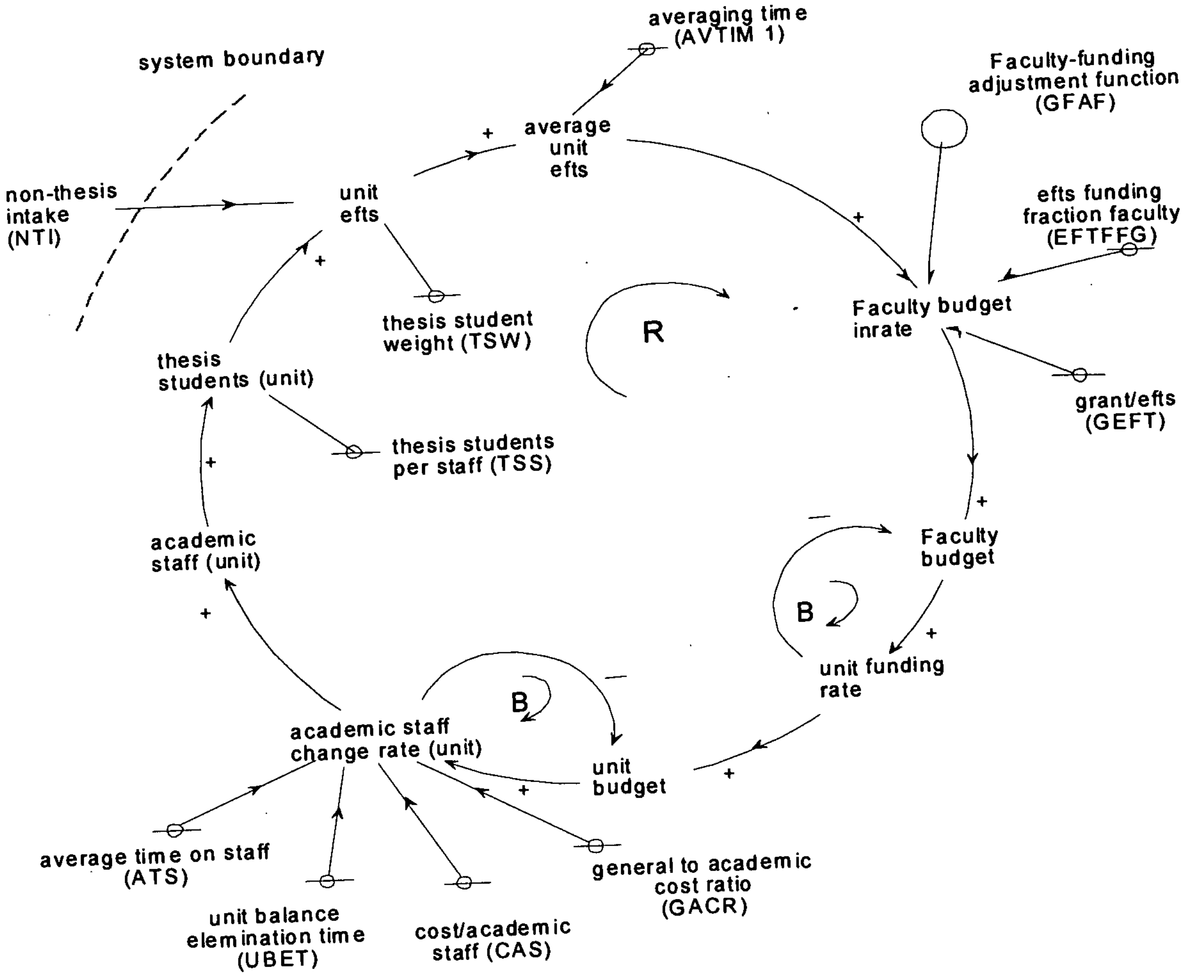


Figure 9. Faculty enrolment funding structure

The reinforcing loop in Figure 9 operates as follows. Suppose that *unit* (school or department) enrollment (efts) rises, for example due to a stimulus from an increase in undergraduate enrollments. This increase affects the three-year average of unit efts, which collectively increases the rate funding the faculty budget and thence the faculty budget itself. From the faculty budget, funds flow to the units via the unit-funding rate so tending to increase the unit budget. This unit surplus is used to increase academic staff with this process targeted over a time frame (e.g. 1 to 3 years) that is also the target period for eliminating a debt or surplus. The increase in academic staff enables the enrollment of more students, which feeds forward to further augment the unit efts. Thus the initial increase in unit efts has set in motion a chain reaction of cause and effect resulting in a further rise in the same quantity.

There are two delays in this loop. Undergraduate course length (e.g. three years), acts as a pipeline delay with respect to students moving through the faculty. Together with funding based on enrolments averaged over (1-3) years, this means that a delay of (4-6) years occurs between the initial enrolment increase and the final year of its flow-on impact to faculty funds. The two small negative loops in Fig 3 indicate respectively that the flow of funds to units depletes the faculty budget and the purchasing and sustaining of academic staff and other costs depletes the unit (school or department) budgets. In both cases an increase in the budget increases the outflow rate leading to a decrease in the budget. The time over which faculty surpluses or debts are targeted for elimination is another internal decision that can vary, again quite typically from 1 to 3 years. Since the main expenditure is personnel, this adjustment time also impacts on the rate at which staff are hired or released.

A university decision-making and resource allocation structure contains many such loops that mutually interact, and together with a range of other loops drive and curtail growth processes. Such complex systems are resistant to interventions and can exhibit counterintuitive behaviour due to the interaction of the multiple feedback loops containing time delays that intervene between an action and its outcome, real or perceived. What can be predicted on the basis of such a basic loop structure is the cyclical behavior of debt and surplus, so ubiquitously experienced by faculties, and transferred to the waxing and waning of staff numbers. This is a consequence of delays, which ensure that balancing loops consistently undershoot and overshoot their targets. The loop diagram contained in Figure 9 includes also parameters (such as CAS, ATS etc) as components of organizational, structure. These serve as fixed numerical inputs to feedback loops, defining quantities such as goals of balancing loops, and analogues of the growth and depletion rates (like interest rates) driving reinforcing loops. It turns out that while outcomes may vary in minor details when parametric values are altered, the nature of the behavior is generally very robust. This can be envisaged by imagining the setting and/or adjustment time of a thermostat controlled heating system being changed. The overall operation of the heating system remains the same, with some small adjustments in the final temperature achieved, and the time taken to reach it. The more complex the system the more difficult to change are the fundamental modes of behavior. This is because there are many loops at work, and dominance shifts, such that if a process deemed detrimental is addressed by the application of a particular policy, other loops kick in to move the behavior back towards the status quo. There are generally very few parameters with real influence, and these most often do not coincide with the intuitions of administrators. This is a manifestation of the *scalpel* metaphor. Our pet theories for achieving change often are embroiled in detail that simply does not matter-system structure not parametric detail governs behavior. Laying out a system structure is a way of identifying the range of feedback at work. If not always providing solutions this activity usually provides new insights into what is going on in the system being modelled. Simulation is the next step in searching for leverage points. Further elaboration of systems thinking in relation to university decision-making is contained in (Galbraith, 1998a; 1998b; 1999).

Envoi

In conclusion it is appropriate to stand back and reflect on the role suggested for systems thinking by the organizational examples introduced. Archetype analysis is probably one of the easier approaches providing it is used responsibly. A danger in carrying a 'bag of archetypes' is the temptation to force their use by fitting circumstances to tools rather than the reverse. An example of "given a hammer, everything becomes a nail".

So it is important to follow the fundamental systems principle of first identifying problem behavior and then seeking its causal origins. Optimistic growth that slows and stalls suggests that 'limits to growth' structures are at work, and the identification and nature of the limiting properties are necessary prerequisites to insightful and pro-active interventions. A problem symptom that waxes and wanes (but is not eliminated), suggests that a 'shifting the burden' structure is operative. Attention needs then to focus on identifying whether some external procedures are regularly employed to keep the problem in check, while a fundamental attack on the problem that involves the strengthening or introduction of internal procedures remains unrecognized or undeveloped. The gradual eroding of the effectiveness of institution wide programs, or steadily decreasing performance on some key indicators suggests that a 'sliding goals' structure and mentality may pervade the organization. Attention is thereby directed to identifying the goals that are being allowed to erode and to locating and strengthening the procedures responsible. Burnout as represented by individuals and institutions working harder and harder for less and less reward, is indicative of 'tragedy of the commons' scenarios when the common resource for which they compete is limited or decreasing. Managing a commons involves responsible collaborative stewardship, and a self-discipline that precludes actors from maximizing individual returns, and letting the devil take the hindmost.

The university examples provide a sense of what systems thinking entails when applied within a large and complex organization. Some insights may be inferred directly from the qualitative structure, for others modeling and simulation is required. Some insights that modeling within such systems have provided include the following:

- Fluctuating financial circumstances of internal units such as faculties and schools direct attention to the internal funding policies of an institution, particularly those that operate on proportional distribution principles, in conjunction with pipeline delays in flows such as course completions. They should not be blamed on sudden changes in external conditions, although such changes may trigger periods of cyclic fluctuations.
- Over optimistic predictions based on policies considered in isolation. For example future accumulated salary savings predictions from a resigned staff member, without adjustment for the cost of lost future research productivity.
- Limited leverage for achieving change is provided by altering weights and parameters. For example altering the balance of rewards for publications versus grants, to encourage greater activity on the part of some individuals and groups, does not achieve the intended rapid transformation of institutional performance. This is because those advantaged by the change when also protected by proportional policies of resource distribution, are able to fend off others attempting to claim a greater share from a diminished base. Expectations need to be adjusted and allocation mechanisms reviewed. If transformation of performance is desired then structures, not parameters, need examination and change.
- Incommensurability of time scales create major stresses on matters such as staffing issues. Income generating cycles may have cumulative time lags of up to a decade when pipeline delays associated with undergraduate degree length, extended thesis candidatures, together with averaging of enrollment data over times of up to three years contribute to income streams. Imposed debt management time-scales on the other hand are much shorter in length, with some unit managers required to maintain balanced budgets on an annual basis. Such incommensurability can have drastic implications for staffing policies and flow on effects to long-term institutional performance and instability.

Conclusions as to the value of systemic analyses are most appropriately considered in terms of the insights achieved, and the bases that are provided for levering and sustaining change in organizational behavior. Is it worth the effort for leaders to develop systemic insights to inform their organizational decision making? In considering costs and benefits it is salutary to reflect, as Senge and Sterman (1994) relate management difficulties experienced by executive administrators challenged to respond to simulated operating conditions representative of their organizational contexts. Business managers generated costly supply-demand cycles even when consumer demand was constant; experienced executives in a simulation of a failed airline destroyed their company just as their counterparts had done in real life; executives from a publishing industry bankrupted their magazine just as circulation reached an all-time high; fire department managers burned down their headquarters despite their best efforts to put out the blaze; and doctors ordered increased tests while their patients sickened and died. The point being made is that understanding and managing the dynamics of a complex system is not a natural by-product of field experience and disciplinary expertise, whether the enterprise is manufacturing, service, or education. Some years ago Forrester (1972) succinctly and powerfully summarized the challenges faced by policy makers and managers in terms of the complexity of system behavior.

> "Complex systems differ from simple ones in being 'counter intuitive', i.e. not behaving as one might expect them to. They are remarkably insensitive to changes in many system parameters, i.e. ultrastable. They stubbornly resist policy changes. They contain influential pressure points, often in unexpected places, which can alter system-steady states dramatically. They are able to compensate for externally applied efforts to correct them by reducing internal activity that corresponds to those efforts. They often react to a policy change in the long run, in a way opposite to their reaction in the short run. Intuition and judgment generated by a lifetime of experience with the simple systems that surround one's every action create a network of expectations and perceptions that could hardly be better designed to mislead the unwary when s/he moves into the realm of complex systems." (Forrester in Miller 1972)

We noted previously that the application of systems thinking to the art and practice of developing and managing 'learning organizations' is a continuing and developing enterprise. However some of the early motivations remain as necessary and elusive today, as they were a decade ago. Senge (1990: 340) captures one such enduring challenge.

> "Our traditional views of leaders – as special people who set the direction, make the key decisions, and energize the troops – are deeply rooted in an individualistic and non-systemic worldview. Especially in the West, leaders are *heroes* – great men (and occasionally women) who "rise to the fore" in times of crises. Our prevailing leadership myths are still captured by the image of the captain of the cavalry leading the charge to rescue the settlers from the attacking Indians. So long as such myths prevail, they reinforce a focus on short-term events and charismatic heroes rather than on systemic forces and collective learning. At its heart, the traditional view of leadership is based on assumptions of people's powerlessness, their lack of personal vision and inability to master the forces of change, deficits, which can be remedied only by a few great leaders.
> The new view of leadership in learning organizations centers on subtler and more important tasks. In a learning organization, leaders are designers, stewards, and teachers. They are responsible for *building organizations* where people continually expand their capabilities to understand complexity, clarify vision, and improve shared mental models – that is, they are responsible for learning."

When we attribute behavior to people rather than to the influence of system structure as Forrester (1994) reminds us, the focus of management becomes the search for extraordinary people to do the job. Rather the challenge should be to design the job so that ordinary people can do it. There seems no better metaphor than 'Leader as

Teacher' (in the sense of fostering organizational learning) to describe those who are prepared to further this challenge.

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